IS 4247-1 (1993): Code of practice for structural design of surface hydroelectric power stations, Part 1: Data for design [WRD 15: Hydroelectric Power House Structures]

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IS 4247 (Part 1) : 1993

भारतीय मानक

पृष्ठीय जल पावर स्टेशन के संरचनात्मक डिजाइन की रीति संहिता

(तीसरा पुनरीक्षण)

भाग 1 डिजाइनों का आँकड़ा

Indian Standard

STRUCTURAL DESIGN OF SURFACE HYDROELECTRIC POWER STATIONS

PART 1 DATA FOR DESIGN — CODE OF PRACTICE

(Third Revision)

UDC 627·85·04 : 621·311·2 : 006·76

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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TO
IS 4247 (PART 1) : 1993 STRUCTURAL DESIGN OF SURFACE HYDROELECTRIC POWER STATIONS

PART 1 DATA FOR DESIGN — CODE OF PRACTICE

(Third Revision)

(*Page* 1, *clause* 2) — Substitute 'IS 7207 : 1992' *for* 'IS 7207 : 1991'.

(WRD 15)

Reprography Unit, BIS, New Delhi, India

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydroelectric Power House Structures Sectional Committee had been approved by the River Valley Division Council.

For the structural design of a power house certain basic data with respect to site of the power house equipment to be installed, the features of operation and materials for construction are necessary, and this standard is intended to serve as a guide for designers in collection of these data.

This standard was first published in 1967. The first revision of the standard was taken up in 1978 and subsequently revised in 1984. This third revision has been taken up to incorporate the changes in light of the experience gained during the last few years to the use of this standard. The important changes are in respect to meterological data and collection of data from layout drawing.

This standard has been published in three parts. Part 2 of the standard deals with the design of superstructure while Part 3 deals with the design of substructure.

For the purpose of deciding whether a particular requirement of this standard is compliced with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STRUCTURAL DESIGN OF SURFACE HYDROELECTRIC POWER STATIONS

PART 1 DATA FOR DESIGN — CODE OF PRACTICE

(Third Revision)

1 SCOPE

1.1 This standard (Part 1) covers the data required to be collected for the structural design of surface hydroelectric power stations.

1.1.1 The data will serve only to proceed with the designs. For preparing final construction drawings further details should be collected at different stages for which constant liaison should be maintained with the equipment suppliers, the electrical/mechanical engineers and architects.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
3177-1977	Code of practice for electric overhead travelling cranes and gantary cranes other than steel works cranes (*first revision*)
4461-1979	Code of practice for joints in surface hydroelectric power stations (*first revision*)
7207-1991	Criteria for design of generator foundation for hydroelectric power station (*first revision*)
10060-1981	Code of practice for subsurface investigation for power house sites

3 GENERAL

3.1 The comparative layout studies should be carried out and the most advantageous layout from technical feasibility and economic consideration should be adopted and designs for the hydroelectric power stations should be prepared for the same.

3.2 The structural design of a hydroelectric power station consists of the following steps:

a) Analysis for stability against static and dynamic loads at various stages of construction and operation;

b) Design of the substructure including foundation;

c) Design of the intermediate structure including spiral casings and generator support;

d) Design of the superstructure including roof; and

e) Design of auxiliary rooms, service bay and any other component where it forms a part of the power house.

3.2.1 The various components and the sequence of construction of hydroelectric power stations are shown in Fig. 1, 2 and 3 are indicative only.

4 COLLECTION OF DATA

4.0 Before the structural design may be undertaken certain data should be collected from the site and from the equipment suppliers. A consolidated list of such data is given in **4.1** and **4.2**.

4.1 Data from the Site

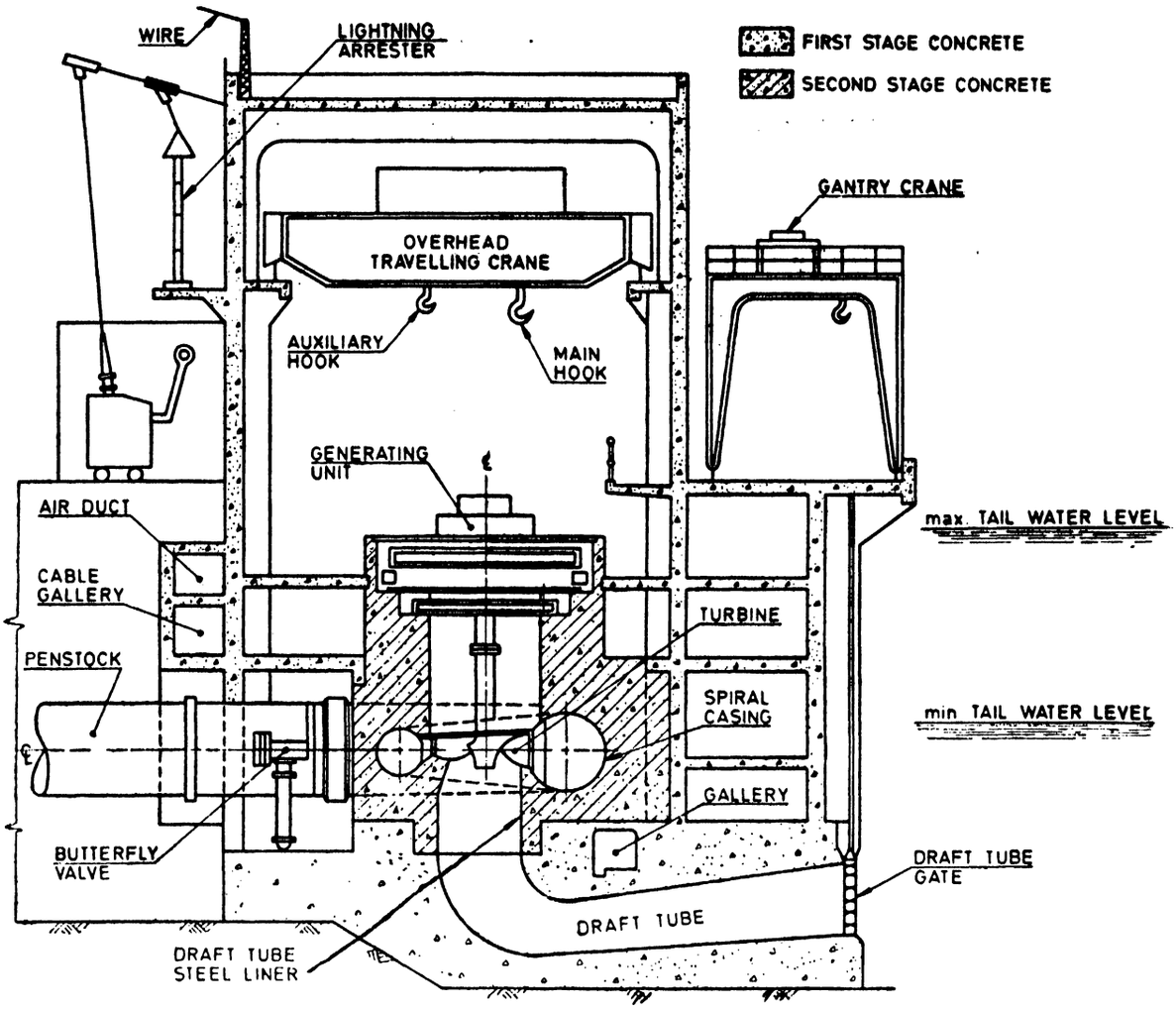
The following data should be collected from the site:

a) A contoured/contour plan of the site on a 1 : 1 000 scale with appropriate contour interval including the location of intake structure, water conductor system, surge tank, if any, power house, switchyard (substation), tall race and any other relevant features.

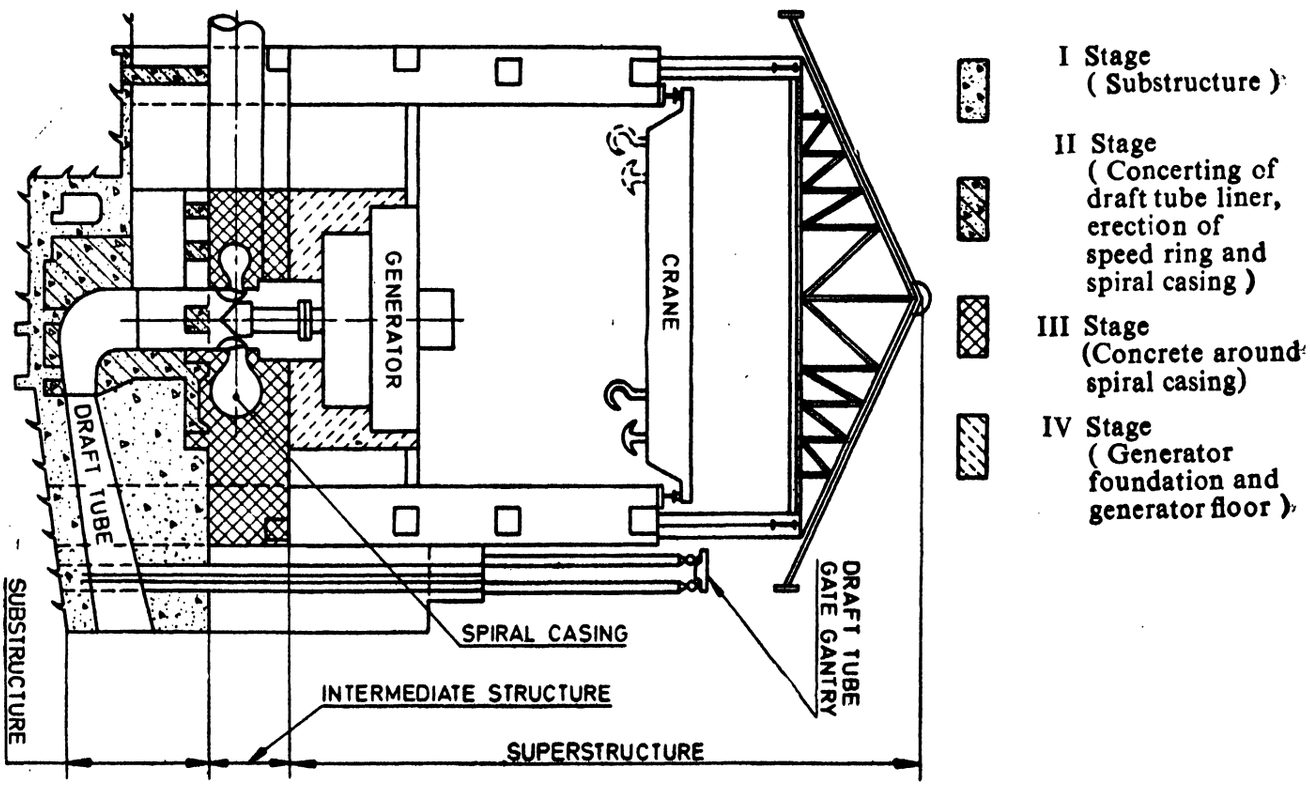
b) A complete longitudinal section of the water conductor system from the intake up to the tail race with maximum and minimum water levels at both ends, hydraulic particulars of the water conductor sytem and any other salient feature occurring in the system.

c) A chart showing the strata below foundtion level approximately to a depth equal to the width of the power house, in addition exploratory boring may be taken to deeper levels, in case of doubtful strata refer to IS 10C60 : 1981.

d) Properties of the soil or rock from surface to foundation level and at lower levels, if weaker strata exist, and permeability characteristics of overburden.



1A Sequence of Construction



1B Alternate Sequence of Construction

NOTE — The sequence of construction may be modified to suit the construction schedule.

FIG. 1 TYPICAL SECTION OF A HYDEL POWER STATION WITH VERTICAL SHAFT REACTION TURBINE SHOWING THE COMPONENTS AND SEQUENCE OF CONSTRUCTION

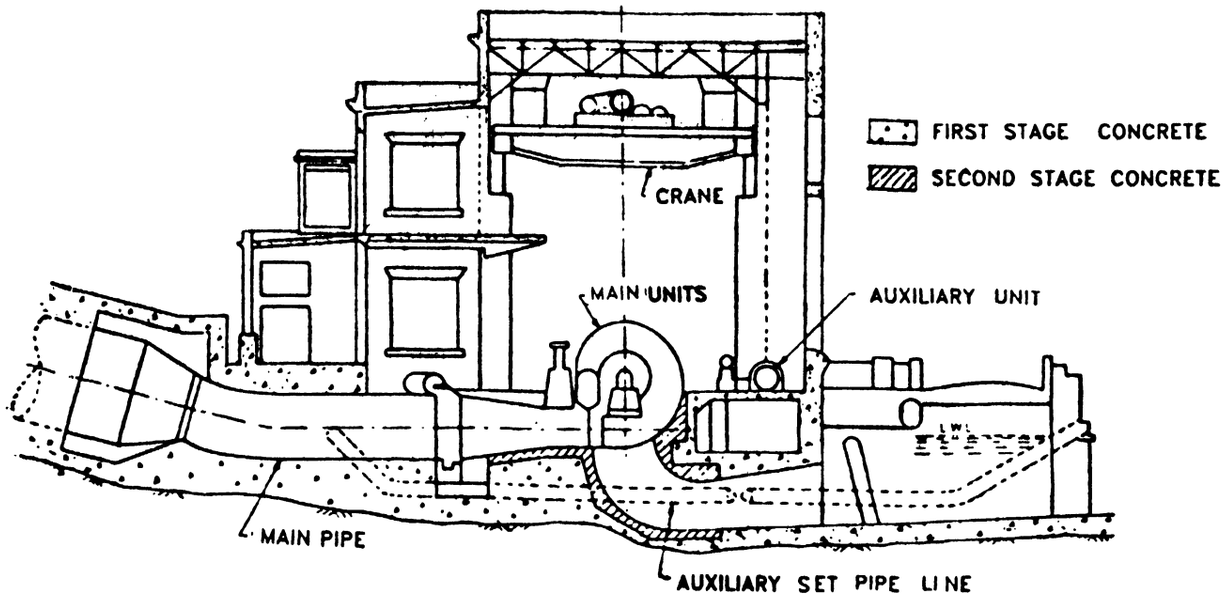


FIG. 2 TYPICAL SECTION OF A HYDROELECTRIC POWER STATION WITH HORIZONTAL SHAFT REACTION TURBINE

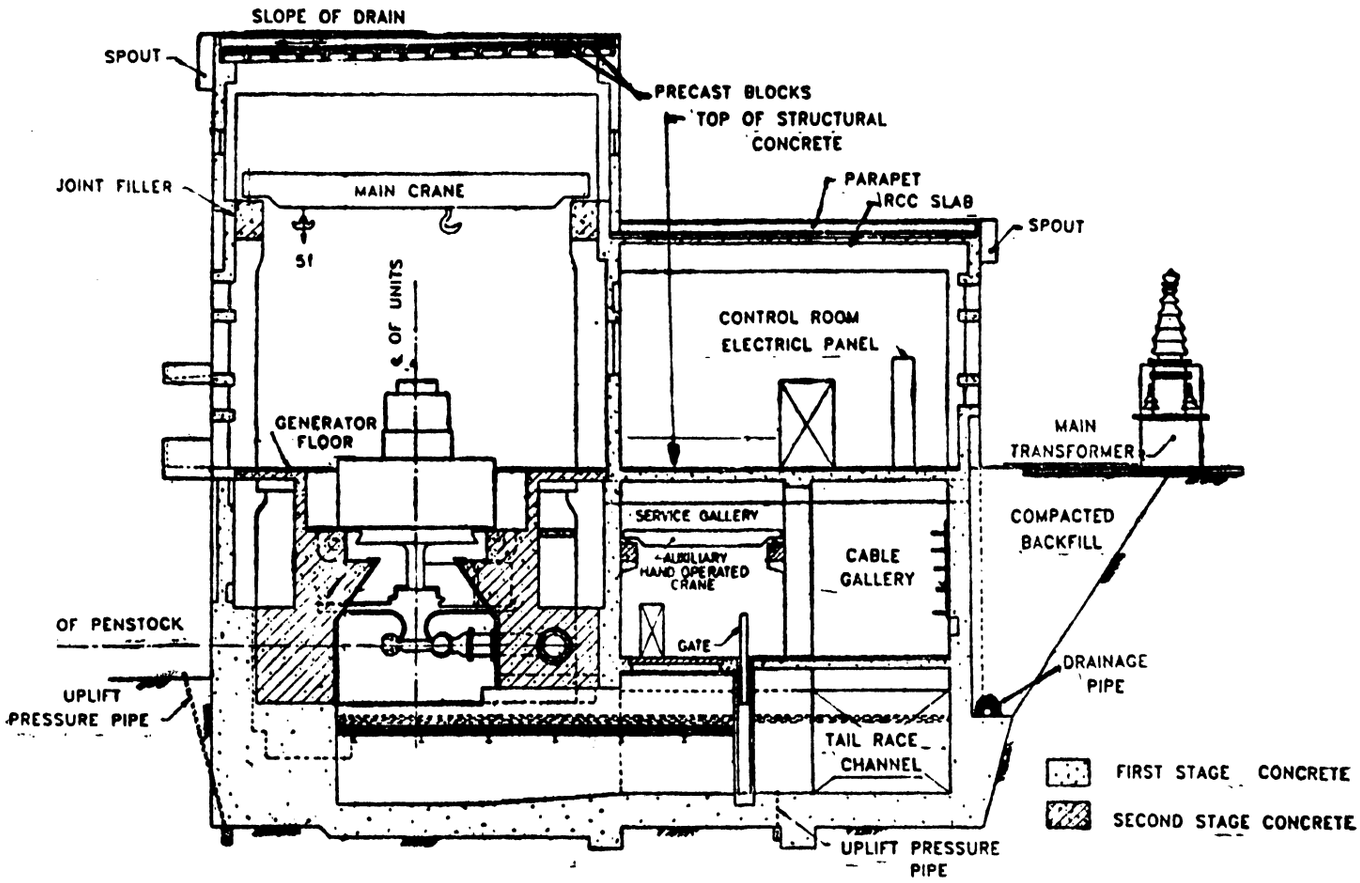


FIG. 3 TYPICAL CROSS SECTION OF A SURFACE HYDROELECTRIC POWER STATION WITH VERTICAL SHAFT PELTON TURBINE

e) The results of load test and dynamic characteristics of foundation strata for the foundation of various structures.

f) Maximum electrical resistivity of foundtion strata observed every month over a period of one year.

g) The coefficient friction between concrete and soil or rock and cohesion of unit shear strength under dry and submerged conditions and also of foundation material along weak shear zones and bedding planes. For preliminary design the values given in Table 1 may be used.

h) Maximum and minimum ground water level based on available data.

j) Physical characteristics of the backfill material, that is cohesion, angle of internal friction, density in dry and saturated conditions, permeability, etc.

k) Geophysical characteristics of the soil or rock (geological information, such as presence of solution cavities, faults, seams, bedding planes, seismic status with parameters and possibility of rock falls).

m) *Meteorological Data*—This may include the following:

i) Monthly minimum and maximum temperature of river water,

ii) Monthly minimum and maximum temperature of ambient air,

iii) Average monthly rainfall and its maximum intensity,

iv) Area of catchment which will drain water through power house site,

v) Values and directions of wind velocity, and

vi) Maximum depth of snowfall.

n) Characteristics and leads of construction materials.

p) Gauge and discharge data carrying observed flood at tail race exit.

Table 1 Values of Unit Shear Strength and Coefficient of Friction

(*Clause* 4.1)

Sl No.	Material	Unit Shear Strength C, *Min*	Coefficient of Friction
(1)	(2)	(3) N/mm²	(4)
i)	Rock (massive and sound)	3	0·80
ii)	Concrete	3	0·80
iii)	Rock (fractured, jointed)	0·7	0·60
iv)	Gravel	0	0·50
v)	Sand	0	0·40
vi)	Clay (hard)	0·07	0·30
vii)	Clay (soft)	0·02	0·20

4.2 The information given in **4.2.1** to **4.2.4** should be finalized by the structural engineer in consultation with the electrical engineer and equipment suppliers.

4.2.1 *Layout Drawings*

These involve the following:

a) Layout of the power house and appurtenant works such as cable tunnel, switchyard, by-pass water conductor system including tail race and access road.

b) General plan of the power house showing the erection bay, control room, offices, workshop, utilities, etc, and other allied structures.

c) Plan at generator floor level showing location of staircases, equipment and openings, etc.

d) Plan at turbine floor level showing location of staircases equipment opening, etc.

e) Plan at centre line of spiral casing showing location of butterfly/spherical valve, expansion joint, etc.

f) Plans showing features such as (i) galleries, (ii) draft tube deck, (iii) Transformers and fire walls, (iv) Transformer and gantry crane rails, (v) Transformer oil drainage pit, (vi) Draft tube gates and gantry crane, (vii) Drainage and dewatering sump, (viii) Water tanks, (ix) Ducts, trenches and openings, etc.

g) Plans of the erection bay, control rooms and cable room showing dimensions of the erection pits, location of control equipment and cable racks, etc.

h) Transverse section (along the flow of water) through the centre line of machines, through the control and administration block and erection bay.

j) Longitudinal section (at right angles to the direction of flow) through the centre line of machines.

k) Longitudinal section showing the upstream galleries.

m) Longitudinal section showing the downstream galleries.

n) Longitudinal section through the control bay, offices, erection bay, etc.

p) The shape and profile of the draft tube and its gated control along with hoisting arrangement and its liner with details of supports and turn buckles and access into draft tube, etc.

q) Shape and profile of spiral casing with details of supports and turn buckles for steel spiral casing including information regarding concreting around the spiral casing, location of access for inspection, etc.

r) Plan and elevations of generator foundations showing details of base plates, anchor bolts, blockouts, etc.

s) Drainage and dewatering arrangement comprising : (1) penstock, (2) draft tube, (3) power house drainage, (4) natural drainage, etc.

t) Location of construction, contraction and expansion joints (*see* IS 4461 : 1979).

u) Dimension, location and arrangement of speed ring supports.

v) Dimension, location and arrangement of inlet valve (if provided) supports.

w) Layout of tail race.

y) Number, dimensions, clearancces of E.O.T. cranes and drawings giving details of the crane.

z) Slope protection in the vicinity of power plant and drainage.

z1) Layout of passage and size of bus ducts.

z2) Layout of airconditioning and ventilation ducts and general arrangement thereof.

4.2.2 *Loads*

The loads imposed by the equipment and accessories should be shown in plan and section such that the point of application of the load as well as its base area are clearly indicated. If during the initial stages it is not possible to give the exact dimensions, orientation and load of the various auxiliary equipment coming on different floors, design for areas listed under Parts A and B of Table 2 may be done for the loads indicated against each area.

4.2.3 The data including loads and forces for which details should be furnished by the suppliers, are as follows:

a) Details of maximum loads and dimensions of generator stator and rotor components, braking and short-circuit torque and unbalanced megnetic pull in radial direction (*see* IS 7207 : 1991) giving information for the following:

1) Vertical load on stator sole plates:

2) Tangential force in direction of rotation on stator sole plates;

3) Tangential force in direction of rotation on stator sole plates;

4) Vertical force on lower bracket sole plates;

5) Tangential force in direction of rotation on lower bracket sole plates;

6) Force due to unbalanced magnetic pull (radial force);

7) Seismic force on stator sole plate;

8) Seismic force on lower bracket sole plate;

9) Impact factor; and

10) Directions and point of applications of above loads.

NOTE – Conditions under which the above loads act should be specified as normal conditions, short circuit of stator, double short circuit of rotor, etc.

Table 2 Minimum Uniformly Distributed Live Load

(*Clause* 4.2.2)

Sl No. (1)	Area of Location (2)	Live Load (3) N/m²
	PART A	
	(The indicated loads include equipment load)	
i)	Roofs : Accessible	1 500
	Inaccessible	750
ii)	Stairways	5 000
iii)	Office and corridors	5 000
iv)	Reception rooms	5 000
v)	Circuit breaker rooms	20 000
vi)	Control room	10 000
vii)	Cable spreading room	10 000
viii)	Equipment and storage rooms	10 000
ix)	Maintenance shop	15 000
x)	Fan room (air-conditioning, heating and ventilating equipment)	5 000
xi)	Auxiliary electric equipment room	10 000
xii)	Steel grating/chequered plate	5 000
xiii)	Tool room	10 000
xiv)	Galleries with light or no equipment, namely, carbon dioxide, drainage (no pump), heat exchanger, pipe, dewatering (no pump), ventilating, battery rooms, motor generator room, operating floors (other than generator floor and telephone room)	10 000
xv)	Water — treatment room	7 500
	PART B	
i)	Erection floor	50 000
ii)	Generator floor	10 000
iii)	Turbine floor	15 000
iv)	Pump rooms and oil purification rooms	10 000
v)	Transformer beck	10 000
vi)	Gantry deck (outdoor power house), intake deck (general), power house access and draft tube deck	10 000
vii)	Air compressor room, penstock and valve floor, generator-protective equipment gallery and switch gear room	10 000

NOTES

1 If the power house is located in snow-bound areas, suitable snow load should be taken into account.

2 The above loading is for preliminary design only. The final design should be checked for the actual equipment load.

b) Machine characteristics comprising of:
   1) normal and runaway speed,
   2) permissible tilt in the shaft, and
   3) opening and closing time of the governor.

c) Load of the inlet valves including its auxiliaries.

d) Load of turbine runner including that of shaft, spiral casing loads (comprising the mass of embedded parts, such as spiral casing, speed ring and cover plates) erection load of the spiral casing liner and the load in empty and full conditions, transferred by each pedestal.

e) Loads induced by the draft tube liner comprising its mass and centre of gravity.

f) Size, load and permissible alternative position, together with details for access and support of:
   1) mechanical auxiliary equipment of the generator and turbine, such as air compressors, oil resrvoirs and cooling water pumps, oil pump tanks ; governors, strainers, drainage and dewatering pumps; and
   2) electrical auxiliary equipment, such as main and auxiliary transformers.

g) Load of equipment coming over the control room and cable room floors.

h) Loads for which the runner and generator supports (in the erection bay) are to be designed.

j) Load and dimensions of the heaviest part/package to be transported in the power house.

k) Erection and live loads on the various floors (*see* Table 2).

m) Details of EOT crane (*see* IS 3177 : 1977) giving information on:
   1) the number and spacing of wheels of crane/cranes, when placed buffer to buffer and clearance required from ceiling and inner face of columns (*see* Annex A).
   2) load and centre of gravity of bridge girders and wheels bogies,
   3) crane surges in longitudinal and transverse directions;
   4) rated capacities and highest levels of main and auxiliary hooks;
   5) load of crane girders with rails and level of top of rails;
   6) load and rated capacity of lifting beams, if provided;
   7) traction forces (both in transverse and longitudinal directions) and impact allowance;
   8) Crane striking forces in longitudinal and transverse directions;
   9) crane testing load; and
   10) method of erecting the EOT crane.

n) Thrust due to servomotors.

p) Jet reaction of pelton turbine.

q) Vertical and horizontal loads of each switchyard equipment along with its supporting structures/towers, pulls of conductors and directions and points of application

4.2.4 *Hydraulic Data*

The following should be indicated:

a) Horizontal thrust due to water to penstock indicating mode of transfer;

b) Water-hammer load due to sudden closure of the machine;

c) Hydraulic thrust in the vertical direction due to water on runner;

d) Velocity diagram along the draft tube; and

e) Pressure diagram along the draft tube during normal running of the machine.

ANNEX A

[*Clause* 4.2.3(m)(1)]

PROFORMA FOR RECORDING DETAILS OF CRANE LOADING

1 Capacity of crane.....

2 Span.....

3 Load of crane without crab along with location of its centre of gravity.....

4 Independent crab load with location of its centre of gravity

5 i) Horizontal distances of main and auxiliary hooks from upstream crane rail when the hooks are at their extreme upstream position.

ii) Horizontal distances of main and auxiliary hooks from the downstream crane rail when the hooks are at the extreme downstream positions.

iii) Horizontal distances of the hooks from the end buffers of the crane.

6 Position of crane wheels, with respect to end buffers

7 Side and vertical clearances.....

8 Number of wheels and wheel spacing.....

9 Wheel loads

i) For unloaded crane with trolley at its upstream most position

ii) For unloaded crane with trolley at its downstream most position

iii) For loaded crane with trolley at its upstream most position

iv) For loaded crane with trolley at its downstream most position

10 Crane surged in transverse and longitudinal distances

11 Striking crane surges in transverse and longitudinal directions

12 Height of the centre line of the end buffers of the crane above the top of the crane rail.

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices:	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	331 01 31 331 13 75
Eastern : 1/14 C.I.T. Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	37 84 99, 37 85 61 37 86 26, 37 86 62
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